

# HEALTH INFORMATION SYSTEMS DESIGN & OVERVIEW

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**PROJECT:** Abt Associates, Inc.  
ZdravReform Program  
Final MIS Products  
PC CCN-004-C-00-4023-00

**Distribution:** Abt Associates, Inc.  
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## **1. Introduction**

The modern digital computer grew out of developments in the United States, Russia and abroad during World War II. But the first practical application of automatic computing relevant to Medicine in the United States dates to Herman Hollerith's development of a punch card data-processing system for the 1890 U.S. Census. His method's were adapted to epidemiological and public health surveys. By 1914, Russia had also begun experimenting with electro-mechanical punch-card data processing technology at the St. Petersburg national Academy of Medicine.

Russia paralleled the path to development of the stored program and wholly electronic digital computers on which the United States embarked up to World War II. Early activity in both countries centered on attempts to construct systems that would assist a physician in his clinical decision making. The earliest work in the United States was probably associated with the MEDNET project at General Electric. The Russian Ministry of Health sponsored automated diagnostic record keeping in the spheres of narcology, and psychology as early as 1952.

Beginning in the early 1960's, the two country's computer develop program in the health sector remained remarkably similar. Teaching Institutions dominated medical system development. Massachusetts General hospital, Latter Day Saints Hospital and Kaiser Permanente were mirrored in their development efforts by Moscow One, National Academy of Psychiatric Medicine-St. Petersburg and Regional Psychiatric Hospital, Kemerovo. During this period, both health sectors utilized the concept of a large integrated or monolithic design in which a single, large, time shared computer supported an entire collection of applications.

By 1965, the two country's paths began to diverge. Driven by the new requirements of financial record keeping underlying the introduction of wide scale medical insurance in the United States; automated computing exploded from the boundaries of academia. Insurance companies and Medicare sent hospitals who traditionally spent 0.24% of revenues on information systems to invest 3% of revenues by 1970. Fueled by post war investment in infrastructure and technology in medicine, the United States also began to develop separate computer systems for individual applications--laboratory, pharmacy, bed control, appointment control entered the market. These systems based on stand alone mini-computers permitted independent development.

Russia however remained with a centrally planned and administered health care system. The roles of medical service deliverer and financier were performed by the Ministry of Health. Budget based record keeping was easily performed via manual accounting systems. Without the pressures of a changing financial payment scheme, Russia remained on its medical system development course charted in the early 1960's.

The lack of mainframe computers in Russia significantly hampered the widespread dissemination of medical application programs well crafted in the academic environment of Russia's leading medical institutions. By 1975, seven regional installations boasted full electronic medical records with results reporting; a version of e-mail and medical problem list transfers. However these prototypes could not be widely duplicated due not so much to the lack of financial resources; as to the lack of technology available in the country.

In the US, medical computing broadened in scope and accelerated with the appearance of the mini-computer by the mid-1970's. These machines made it possible for individual clinical departments to reorganize their record keeping, and statistical analysis into automated processes. The mini-computer put more computing power in the hands of more medical investigators than did any other single development until the introduction of the microprocessor. The entire bill was paid for through the US health insurance system of cost reimbursement. All advances, no matter how effective, were paid for through the US system of third party reimbursement.

In general, Russia has skipped this entire phase of medical computing. The minicomputer, UNIX operating systems, and standard language software programs were unavailable to the Russian health sector. By 1980, Only a handful of medical institutions were still engaged in the transformation of their care processes to automated systems. However, the Public Health Sector through the epidemiological branches of the Ministry of Health were developing standard data programs to track all at risk populations throughout their continuum of care. Although Russia did not have the commitment to spent upward of 7% of health care resources on information system development, as did the US, they foretold the importance of population based tracking systems which would be managed care's "call-to-arms" in the US by the 1990's.

However, with the introduction of mandatory health insurance legislation in 1991, Russia created a management process of relationships between providers of medical services and newly authorized payers for these services. These new contractual relationships depend upon the rapid exchange of information to properly account for the uses of new flows of money. Similar to the requirements of Medicare and private insurance in the 1960's; Russian health sector has turned to computer technology to meet its rapidly increasing information needs. By 1994, 24 Territorial Funds responsible for providing employer sponsored insurance installed microprocessor network technology to help account for premiums of over 40 million workers and non-working beneficiaries of mandatory health insurance. Over 2,000 hospitals installed personnel computers to help prepare bills for payment of their medical services.

## **2. Current Development Trends**

Current development of information systems in both Russia and the United States fall within eight (8) major categories of process management. Computer systems help health professionals within the following range of functions: (1) data

acquisition, (2) record keeping, (3) communication, (4) surveillance, (5) information storage and retrieval, (6) data analysis, (7) decision support, (8) education. With the exception of surveillance, Russia lags far behind US development efforts within the health sector.

The most obvious reason for this is the Russian government's decision to limit financing of health care. Russia spends only three to four percent of gross domestic product on health care. The US spends 13 to 14 percent. Information systems are but another under-financed component of health services in the Russian federation. But while the deployment of medical computer technology remains narrow; the breadth of medical software applications is quite deep.

## **2.1 Data Acquisition**

Laboratory, pharmacy and radiology technicians in the US could not keep up with the growing demand for test results by utilizing manual techniques. Further, the legal environment of medical malpractice requires an ever lowering tolerance level for mistakes. This environment encouraged researchers to develop automated instruments for collecting empirical medical data. The use of patient monitoring systems ensure that vital signs, EKG's and other indicators of patient status are measured frequently and consistently. This technology is standard practice in most all of the US's 10,000 medical centers.

Russia has also adopted this technology, albeit on a much smaller scale. Eight diagnostic centers, regionally dispersed throughout the country, afford Russia the same level of technological advancement enjoyed by even the most technology laden hospital in the United States. However the majority of Russia's 20,000 hospitals do not employ patient monitoring systems which represent technology available in the US even in the 1960's. Automated laboratory systems, radiology systems, patient monitoring systems and health assessment systems utilize old and unreliable technology. It is not uncommon to see vacuum tube x-ray machines in use next to laproscopic surgical equipment in many provincial hospitals.

The Russian Ministry of Health recognizes the first priority for infrastructure investment relates to replacing medical instruments and equipment. The Ministry of Health and Medical Industry is organizing a capital investment program in conjunction with the World Bank. Investment in 1996-1998 of \$110,000,000 is estimated to meet only 15% of the demand. Automation of medical systems is well suited to this task of performing tedious, repetitive processing, all universally used in medical offices, hospitals, and insurance companies. Management tasks of collecting, tabulating and transcribing data from one form to another are performed routinely by computers. Automated billing systems are the most prolific examples of such systems. These systems lead directly to reduced direct labor costs.

In Russia, the average salary of a record keeper is \$30 per month. Until the most recent price reductions in personal computers and standardized software, direct labor has been less expensive than automation in the area of record keeping. Further limiting the substitution of technology for manpower are Russia's employment laws. Workers are still generally protected with vestiges of the

"employment-for-life" statutes of the soviet regime. The result has been that only few functions of record keeping have been automated. Registration of insurance policies, registration of population in special groups, i.e. Chernobyl survivors, World War II survivors; and data related to infectious disease management are widely automated through special computer procurement programs for all rayons within the Russian federation.

Unlike the United States, record keeping within hospital departments and clinical service departments of polyclinics remains rare in Russia. In the US, most laboratories use computer based information systems to track and report results. This is atypical for most community based hospitals in Russia. But with the continued reduction in price for processing technology, Russian health care administrators are beginning to make more cost-effective decisions. The burden of direct labor expenses is driving medical facilities to look for record keeping alternatives within automated systems.

## **2.2 Communication**

In hospitals, clinics and medical insurance environments in the United States myriad data are collected by health professionals both concurrently and retrospectively with patient encounters. The medical record is the primary tool which facilitates communication among medical personnel. Abstracts of this information are the primary source of data used by insurance companies to transfer money to providers. A critical limitation of the traditional medical record is the concentration of information in one location; which prohibits simultaneous access by multiple people with various management purposes.

The United States program of information system development added to this limitation during the 1970's and 1980's through its reliance on single use minicomputers. Laboratory systems, pharmacy systems and radiology systems did not link with appointment systems and hospital bed management systems. Redundant data in closed architectures extensively reduced the cost-effectiveness of medical information systems.

Within the past half decade, the emergence of managed care and the development of local area networks and "Health Level Seven" information protocols have served to connect before incompatible systems. Communication of vital information among providers and payers is less and less burdened by incompatibility.

In this respect Russia is currently avoiding the phase of US information system development characterized by high investment costs and low practical returns. Russians, by choice or circumstance avoided the cumbersome, impractical and costly mainframe and minicomputer applications which dominated the United States during the 1970's and 1980's. Russia is substituting client server microprocessor technology directly for their manual systems in use during the past five decades.

Russia is spending approximately the same relative per capita percentage on computerizing their communication functions as is spent in the United States. Russia spends approximately 7% of health care expenditures on automating clinical and financial information systems. Because the base is \$75 per person per year rather than \$3,000 as is the case in the US, the results of their process are not as discernible as those in the West.

## **2.3 Surveillance**

Data overload is as detrimental to good decision making as is insufficient access to data. Health professionals in the United States are in the midst of developing surveillance and monitoring systems which translate data into information and knowledge. The primary building block for this process is the conversion of data into a digital format. Laboratory systems routinely distribute results into normal and abnormal cohorts and automatically report abnormal results for special follow-up. A pharmacy system which maintains digital records on patients can screen incoming drug orders and warn physicians who orders drugs which interact with another drug the patient is receiving.

This second generation process results from applying digital rules of logic to existing data bases. The resulting information is culled from the flood of data which remains difficult to analyze manually due to its sheer volume.

The development of similar Russian systems has equaled or surpassed the development of artificial intelligence systems in the United States. The deployment of those systems has not even begun to approach the volume of systems routinely used by medical offices and hospitals in the most rural parts of the United States.

The Russian health sector boasts of examples of systems which apply decision algorithms to patient data sets to assist in both the diagnostic and therapeutic processes. Automated drug proscribing, standard treatment protocols matched to primary, secondary and complicating diagnosis are routine in a handful of experimental Russian medical facilities. This system exists next to one which does not provide the routine care giver proper quality control laboratory results for blood type, or basic chemistry analysis. Basic laboratory and x-ray results generated in primary care settings are generally ignored by specialists and hospitals due to their lack of reliability.

Russia supports system development on the experimental level rivaling the most innovative activities at Columbia Prespreteryian or Beth Israel Hospitals while ignoring fundamental needs throughout the organization of primary care and polyclinics.

The United States medical marketplace continually challenges information innovators to provide practical value to mainstream caregivers. The resulting gap between development and widespread deployment is narrow. In Russia, the gap is as large as the Grand Canyon.

## **2.4 Data Analysis**

The United States health sector is deeply involved in developing systems that aid decision makers by presenting information in a form that is more understandable than are the raw data. Data are presented graphically to facilitate trend analysis. Analytical systems may compute secondary parameters (means, standard deviations, rates of change, and so on) from the primary data. This body of information is presented in a fashion digestible by the manager responsible for the clinical or financial decision at hand.

Russian health leaders also rely on statistical analysis of large sets of data. However decision makers do not generally display results for easy understanding. The process of relying on "expert" interpretation substitutes for consensus building and persuasion.

The Russian approach is prone to dependence on individual opinion rather than empirical results demonstrated through scientific methodology. However, the information system tools utilized both Russian and United States analysts are very similar. Spreadsheet, statistical and data base management programs based upon microprocessor computing dominate the work of experts in both health sectors.

## **2.5 Education**

Rapid growth in biomedical knowledge and the complexity of therapy management in the United States has produced an environment in which students and practitioners cannot learn all they need to know during training. US physicians and nurses have available to them computer programs designed to help them acquire and maintain knowledge and skills they need to care for their patients.

Easily understandable graphical user interfaces have made easy access to library of medicine professional journals. Up to date resource materials are available to even the most remotely located physicians and medical practitioners.

The Russian health sector has all but ignored knowledge building among its medical professional staff. Either through a lack of financial commitment or managerial neglect; Russian physicians lack access, and incentive to engage in knowledge acquisition. While Russia graduates more physicians per capita than any other country in the world, the vast majority remain relatively ill-prepared to meet the diagnostic and therapeutic needs of the population they serve.

## **3 A Methodology For Development**

The underlying principle of developing information systems in the Health Sector is to reduce uncertainty in decision making by policy makers and managers. The Health Sector in general incorporates three critical management processes: a) maximizing the quality of clinical services delivered to patients by care givers, b) maximizing the consumer's utility (satisfaction) with Health Sector performance, and c) maximizing the financial performance of the system. Information systems must support decisions by policy makers and managers which better predict hoped for

outcomes in activities concerning quality, consumer satisfaction and financial performance. The ZdravReform program, funded by the Agency for International Development (AID) and implemented by Abt Associates, Inc., is a multiyear program that provides collaborative support between US and Russian interests to develop, test and refine such information systems.

These Russian American partnerships are focused on developing both the conceptual framework of information technology as well as practical applications of information systems which improve both the financial and clinical return-on-investment of health care resources. This paper presents a methodology for developing a conceptual framework of information system requirements to support health sector restructuring.

Perhaps most important in designing such a framework is the task of establishing roles and responsibilities of the various governing bodies and regulators of producers and consumers of health sector goods and services. Only then can information technology be designed and coordinated to meet the requirements of these organizations which complement rather than contradict their respective governance functions.

Within the highly privatized market oriented system prevalent in the United States the marketplace determines many of the roles and responsibilities within parameters set forth in legislation. Information systems developed in this environment reflect the patchwork and overlapping nature of the organizations they are meant to serve. But as legislation within Title XVIII and Title XIX (Medicare and Medicaid, respectively) define specific roles and responsibilities of patient, medical providers, medical goods suppliers, insurance and purchaser interests, ***national*** parameters of information standards and management reporting are emerging. Information systems to support DRG payment systems, and cross state management of beneficiary information have become standard information system applications. ***State level*** legislation regulating the operation and reporting requirements of health insurance companies sometimes complement, but often contradict roles and responsibilities of purchasers, payers, providers and consumers of medical care services. Laid atop this web of management control are the requirements of non-governmental authorities which accredit and measure the performance of ***health sector operations***.

Even within in the traditional vertical hierarchy of Russian Health Sector management practices, clear roles and responsibilities of managing finances, supervising health care operations and servicing the patient-consumer are ill-defined and disintegrated. The Federal Fund enabling decrees support person based tariff collection and distribution of financial resources to insurance companies and medical facilities. The Ministry of Health supports the collection of incompatible data revolving around the maintenance of normative volumes of prescribed services. Oblast and municipal budgets still utilize different information organized around the principals of departmental and facility line item budgets.



Clients of information technology then generally fall within 5 categories of users regardless whether their content address quality, financial or consumer concerns.

1. National Health Care Information Systems
2. Regional Health Care Information Networks
3. Facility-Payer Information Systems
4. Accountable Physician Information Systems
5. Individual Patient Information Systems

The organizing principle of this frame work is that data and information at the core of level 5 networks i.e. those at the individual patient record level; serve as the basis of information for level 4 networks; the panel of patients under a responsible physician's care. Information about a group of responsible physicians is the building block for polyclinic and hospital information systems. Catchment areas are then the sum of information gathered at the facility level. These comparable regions then report information to the national level. Information which is gathered and processed at level 5 about a patient is summarized at a physician level i.e. about 2,000 patients. Facility information is then summarized around departments of responsible physicians and so on.

The second principle in creating a logical structure for information technology development is whether to orient system around producers or consumers. Traditionally health sector information systems have been oriented around producers. Hospital systems, laboratory systems, department budget systems are examples of information systems which focus on volume, cost, and price reports of non-integrated component parts of the health sector. HMO patient record systems and medical insurance beneficiary tariff systems focus on longitudinal records-both clinical and financial of the individual. These type of systems are known as person oriented data systems.

In Russia, data collection and processing have encompassed the departmental approach especially with regard to financial monitoring and measuring systems. The health Sector still makes use of predominately static budgets and catagorial financial transactions. The introduction of mandatory health insurance have seen the rise in some capitated sytems of transferring resources; with the resultant effort to develop information systems which support different means of mnonitoring financial transactions.

However, without the careful planning of open architecture information systems the person oriented approach predominenet in epidemiological record keeping will be incompatible with the departmental approach prevelent in facility and regional management systems. With regard to the precept of "orientation", flexibility in design and operation of information technology must reflect the current and future dicotomy of systems. The question of whether one wants to manage hospitals or patients utilizing hospital services is a perspective with no clearcut priority. So information systems must serve both masters without creating incompatible system architecture.

The final characteristic in establishing an information technology methodology, after scale and orientation, is “function”: whether systems support quality, finance, or consumer management processes. Information technology which supports decision making is most effective when data is used to create knowledge about how finances relate with quality; how access and patient satisfaction vary according to quality and finance. So systems must cut across department or person oriented applications on every level (1-5) of magnitude.

Even though the business of providing and financing health care to 150 million people is an extremely complex series of relationships among over 16,000 organizations and 4,000,000 people there remains no more than three elemental functions to be monitored, measured and managed. Money flow; services are provided and communities of patients receive degrees of value or “utility”. Information systems attempt to provide data and knowledge about the convergence of these processes in their interactions either on a transactional level or a strategic level. All systems in some degree fit within these three generic management functions.

#### **4. Program Recommendations**

Specific areas of authority and responsibility for setting information standards must be developed within the Russian atmosphere of a highly decentralized health sector. Much design work remains in order to begin the process of integration